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WIND-TUNNEL INVESTIGATION OF A SPOILER-SLOT AILERON ON AN NACA 23012 AIRFOIL WITH A FULL-SPAN FOWLER FLAP

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SUMMARY

An investigation was made in the NACA 7- by 10-foot wind tunnel of a spoiler-slot aileron on an NACA 23012 airfoil with a full-span 30-percent-chord Fowler flap. The static rolling, yawing, and hinge moments were determined and are presented for several angles of attack and flap deflections.

The characteristics of the spoiler-slot aileron of the present investigation are essentially the same as those of the same device on the airfoil with a full-span NACA slotted flap as tested in a previous investigation. Up-rigging the ailerons, however, as the flap is deflected may be desirable. The test results indicate that the spoiler-slot aileron will provide acceptable lateral-control characteristics for airplanes with full-span Fowler flaps.

INTRODUCTION

The NACA is investigating many different types of lateral-control device for use on wings with full-span high-lift flaps. During the early days of the investigation, full-span split flaps were employed. One of the most promising arrangements developed was the plain aileron and retractable split flap. (See references 1 and 2.) In a more recent investigation, wind-tunnel tests were made of plain ailerons on an airfoil with a full-span flap consisting of an inboard Fowler and an outboard retractable split flap. (See reference 3.) This arrangement is to be flight-tested in the near future.

Wind-tunnel tests have also been made of plain and slot-lip ailerons on an airfoil with a full-span NACA slotted flap (reference 4) and on an airfoil with a full-span flap consisting of an inboard Fowler and an outboard slotted flap (reference 5). At least one of these arrangements is soon to be flight-tested.

Another promising device developed in the wind tunnel is the spoiler-slot or plug-type aileron. (See reference 6.) This device is rather unconventional structurally but provides a lateral-control system that appears to be as simple mechanically as conventional ailerons. It is now being built for flight-testing on a wing with a full-span NACA slotted flap.

In the present investigation, wind-tunnel tests were made of a spoiler-slot aileron in an airfoil with a full-span Fowler flap. Static rolling, yawing, and hinge moments were determined at several angles of attack and flap positions.

APPARATUS AND METHODS

The tests were made in the NACA 7- by 10-foot wind tunnel at a wind velocity of about 40 miles per hour (test Reynolds number 1,500,000) on the 4- by 8-foot NACA 23012 semispan model used in the investigation reported in reference 6. The model was modified for a 0.30c full-span Fowler flap as shown in figures 1 and 2. The Fowler flap, which has a Clark Y airfoil section, was so deflected that the nose point was 1.5 percent of the main airfoil chord below the trailing edge of the main airfoil. The spoiler-slot aileron of this investigation is the same as arrangement B of reference 6 except for larger clearances of the aileron in the slot.

Calculations of the rolling, yawing, and hinge moments were similar to those of reference 6. The values of lift coefficient were computed from the outboard vertical reaction measured in the tunnel. In the computations a lateral center of pressure at 0.45 semispan was assumed.

RESULTS AND DISCUSSION

The following symbols are used in the presentation of results:

C_L lift coefficient $\frac{L}{qS}$

$C_{l'}$ rolling-moment coefficient $\frac{L'}{qbS}$

$C_{n'}$ yawing-moment coefficient $\frac{N'}{qbS}$

H_a aileron hinge moment, inch-pounds at 40 miles per hour

c airfoil chord

b twice span of half-span model

L twice lift of half-span model

S twice area of half-span model

L' rolling moment about wind axis

N' yawing moment about wind axis

q dynamic pressure of air stream

α' uncorrected angle of attack

A positive value of L' or $C_{l'}$ corresponds to a decrease in lift on the model and a positive value of N' or $C_{n'}$ corresponds to an increase in drag on the model. A downward deflection of the aileron is considered positive and hinge moments are considered positive when they tend to deflect the aileron in a positive direction, as in the case of conventional ailerons. Twice the actual lift, area, and span of the model were used in the reduction of results because the model represents half of a complete wing. No corrections have been made for the effect of the tunnel walls. Such corrections may be rather large for the model installation used in these tests.

The rolling-, yawing-, and hinge-moment characteristics of the spoiler-slot aileron at various angles of attack and flap deflections are given in figure 3. The positive deflection range of the aileron produced a small adverse rolling-moment coefficient, which, in the complete system, would decrease the net rolling-moment coefficient. The positive deflection range is useful, however, for counteracting the hinge moments produced by the negative deflection range. (See reference 6.) These results are essentially the same as those of the same device on the airfoil with a full-span NACA slotted flap as reported in reference 6, with the exception that the aileron appears ineffective at low deflections, particularly with the flap deflected 40°.

Unpublished data of flight tests of somewhat similar lateral-control devices did not show the ineffectiveness at small deflections that appeared in the wind-tunnel tests of those devices. If the ineffective region (fig. 3(c)) appears in the flight tests, it may be desirable to uprig automatically the ailerons about 10° when the flap is deflected 40°, in accordance with the suggestion for the split-flap arrangement in reference 6. The yawing-moment data of figure 3(c) indicate that the drag incurred by the recommended uprigging might not be detrimental. A system employing the spoiler-slot aileron and full-span Fowler flap (with the recommended provision for uprigging the ailerons if necessary) appears to be satisfactory on the basis of wind-tunnel tests presented herein.

The steep slopes of the hinge-moment curves near neutral (fig. 3(b) indicate that the aileron control will feel stiff at small deflections. These steep slopes are characteristic of the aileron arrangement tested (see arrangement B in reference 6) and may be avoided if the aileron is so constructed as not to project far below the lower surface of the airfoil. (See arrangement A, reference 6.)

No lag tests were made in this investigation; tests of reasonably similar devices (reference 7) showed the lag to be not too great for satisfactory operation.

An illustrative example of the application of the data to a complete airplane installation is omitted from this report because of the close similarity of the data with those of reference 6 in which an illustrative example was given.

CONCLUSIONS

The characteristics of the spoiler-slot aileron on the airfoil with a full-span Fowler flap as tested in the present investigation were substantially the same as the previously reported characteristics of this device on the airfoil with a full-span NACA slotted flap, with the exception that the aileron appears ineffective at low deflections, particularly with the Fowler flap deflected 40°.

The ineffective region, if present in flight, could be eliminated by a provision in the aileron linkage for automatically uprigging the ailerons as the flap is deflected.

If flight tests prove that the spoiler-slot aileron is satisfactory in combination with an NACA slotted flap, it is recommended that flight tests be made of the device in combination with a full-span Fowler flap in order to realize the high maximum lift that this flap should provide.

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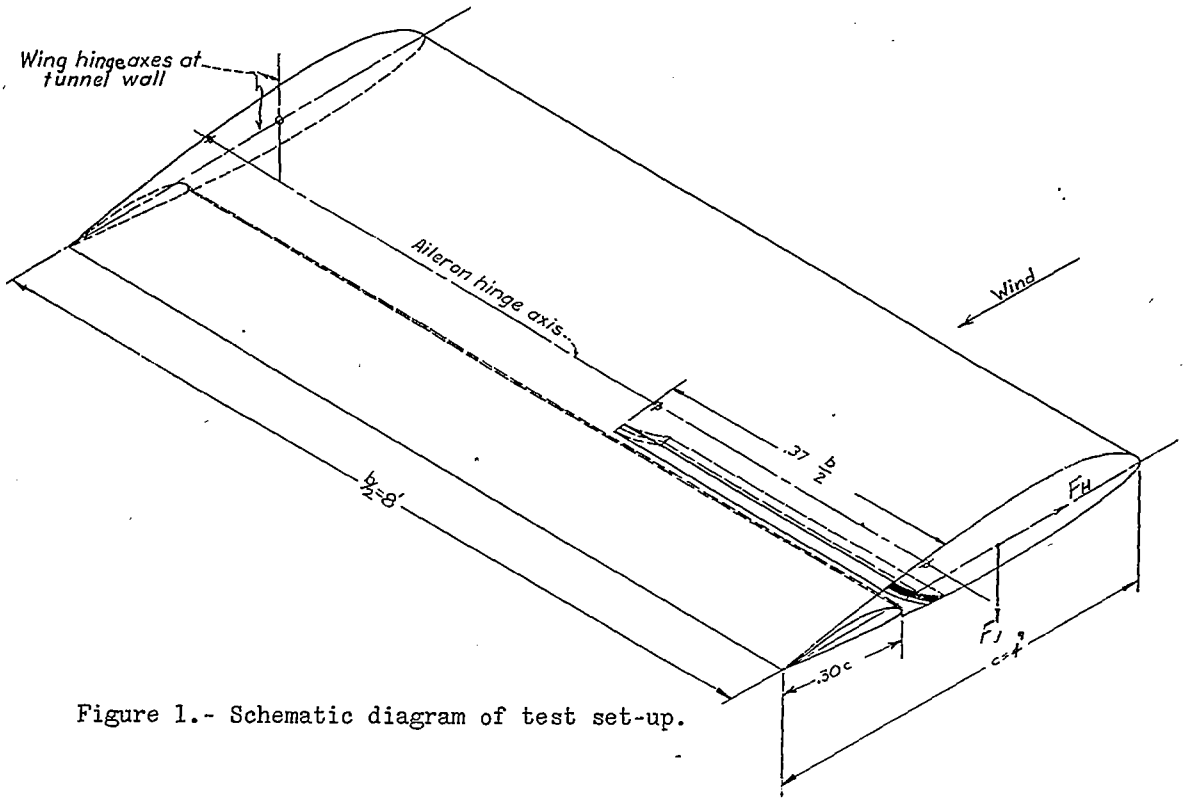

Figure 1.- Schematic diagram of test set-up.

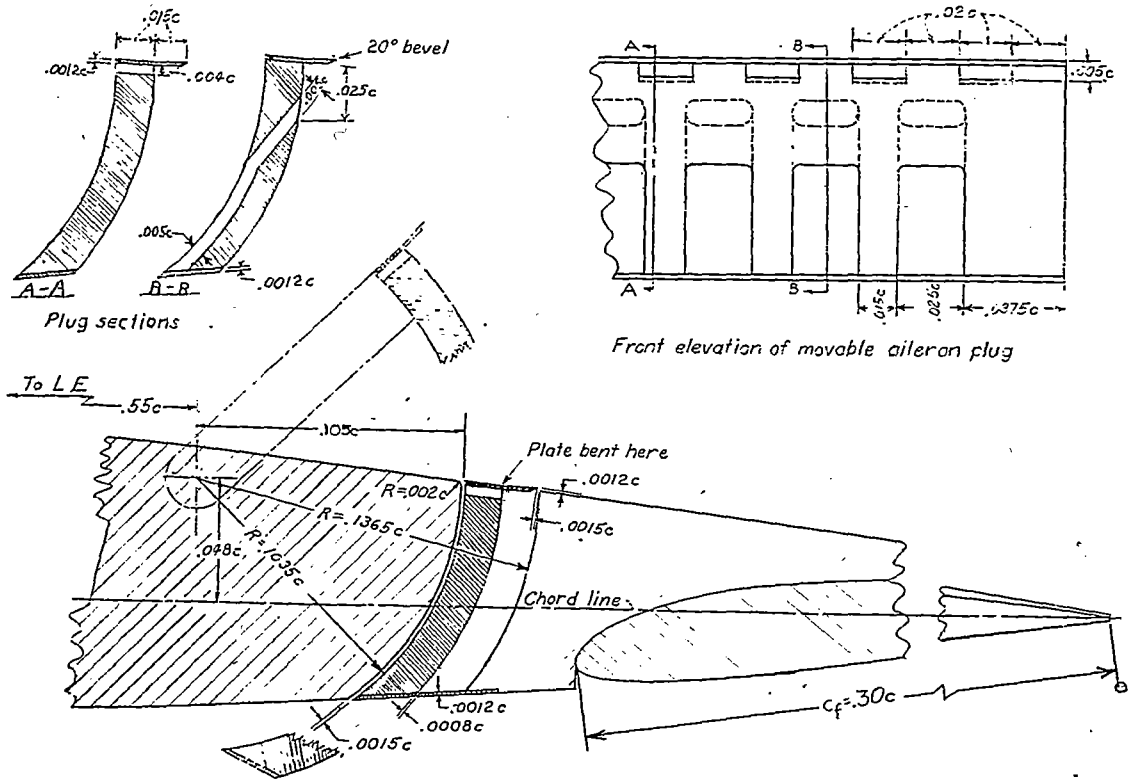

Figure 2.- A 0.37 b/2 spoiler-slot aileron on an 8-foot semispan NACA 23012 airfoil with a 0.30c full-span Fowler flap.

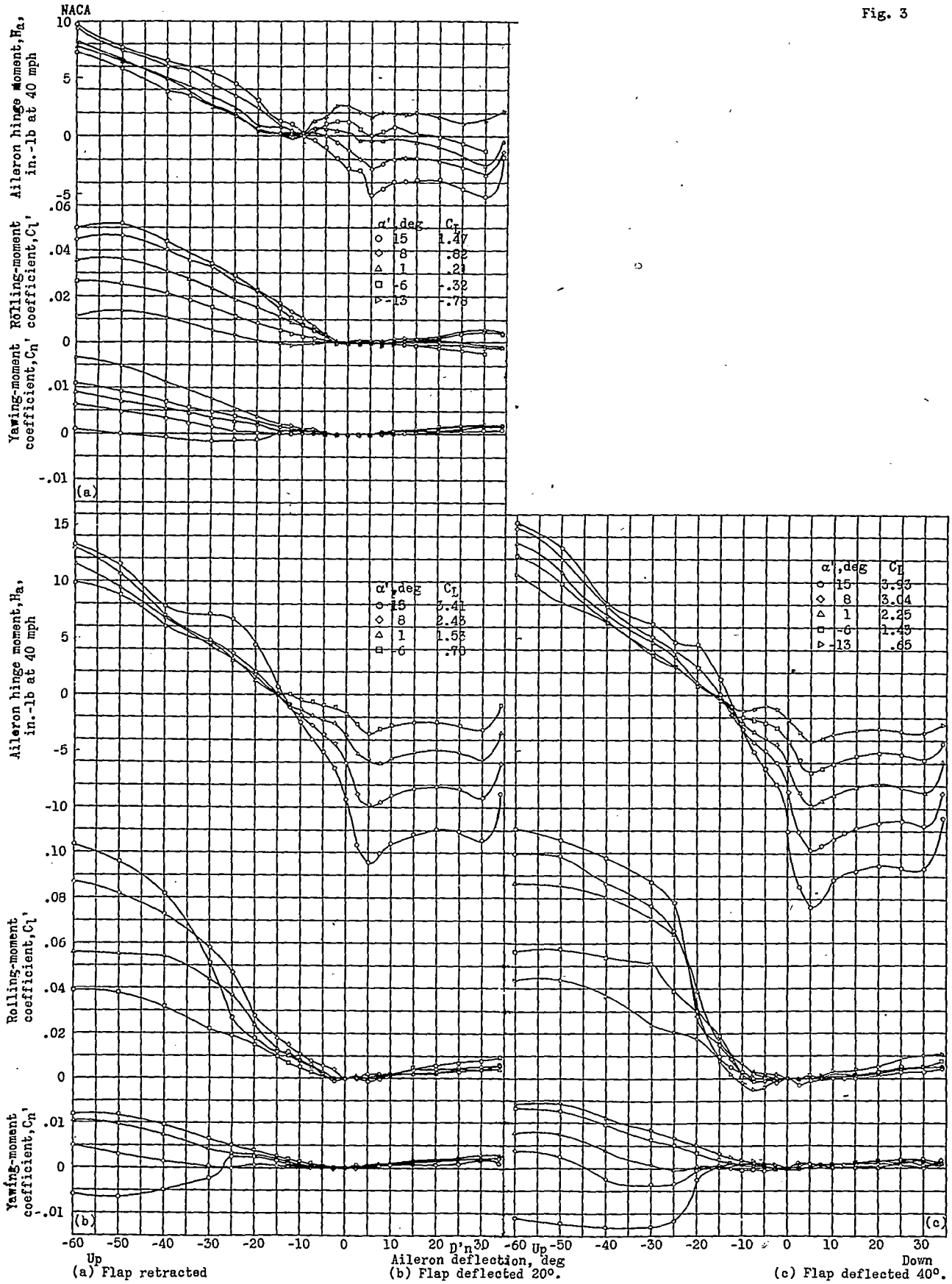

Figure 3.- Aerodynamic characteristics of a 0.37 b/2 spoiler-slot aileron on an NACA 23012 airfoil with a 0.30c full-span Fowler flap.